Abstract View

COMPUTATIONAL CONSEQUENCES OF PARALLEL-FIBER NOISE FOR CEREBELLAR CALIBRATION OF THE VOR

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The accuracy of the horizontal VOR requires that the motor commands to eye muscles compensate for dynamic properties of the oculomotor plant. We have shown that an adaptive filter implementation of the Marr-Albus architecture for cerebellar cortex can learn this plant compensation task (Dean et al 2002). Here we extend that study to investigate the effect of noisy parallel fibre (PF) inputs to the Purkinje cell (PC). The results are illustrated by computer simulation.

We present a computational analysis of the covariance learning rule at PF/PC synapses and show that, given additive noise on PFs, learnt synaptic weights are proportional to root mean square PF signal and inversely proportional to mean square PF noise. This minimises the contribution of PF noise to errors in PC output.

As a consequence PFs carrying noise alone have their synaptic weights driven to zero. Experimental evidence indicates that 80-85% of synapses are in fact silent (Isope and Barbour 2002). This high proportion of silent synapses is consistent with a high proportion of PF's carrying information irrelevant to the task of any given PC.

A further computational implication of PF noise arises from the constraint that PF/PC weights have fixed sign; this requires the PC to have a duplicated set of PF inputs of opposite sign, perhaps corresponding to PC input via inhibitory interneurons (Jörntell and Ekerot 2002).

If most weights are initially zero, learning a new task necessarily proceeds mainly via LTP. Hence the site of synaptic plasticity depends on the direction of the change to be learnt, that is, whether the task requires LTP in the direct or indirect PF pathway. We suggest that this effect may be related to observed asymmetries in learning VOR gain increases or decreases (Boyden et al 2004). Furthermore, during subsequent learning of related tasks, newly active synapses become available for LTD. This may contribute to hysteresis effects where learning rates depend on previous learning history, e.g. acquisition and reacquisition following extinction in eyeblink conditioning.

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